SHASTA RIVER PRELIMINARY ENGINEERING REPORT FOR FISH SCREENING/PASSAGE IMPROVEMENTS

Great Northern Corporation
Weed, CA

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Cascade Earth Sciences, Ltd.

CASCADE EARTH SCIENCES

A VALMONT INDUSTRIES COMPANY

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1.0 PURPOSE AND AUTHORIZATION

The Shasta River has long been recognized as one of the most important spawning tributaries in the Klamath Basin. Due to declines in spawner returns of the fall chinook, the Shasta River Coordinated Resource Management Plan (CRMP) was formed. The goal of the Shasta River CRMP was to improve the survival of salmon and steelhead in the Shasta River and its tributaries.

The CRMP has determined that irrigation diversion dams along the Shasta River may be contributing negatively to water quality for fish. The CRMP plans to assist willing landowners with removal or improvement to irrigation diversions to improve water quality. The ultimate goal is to remove impediments to the passage of anadromous fish and reduce the potential for thermal warming of the stream.

Cascade Earth Sciences (CES) was retained by the Great Northern Corporation, in cooperation with the U.S. Fish and Wildlife Service, to evaluate options for removal or improvement of five of these dams relative to fish passage and screening. This report has been written to document this effort. The five dams evaluated in this report are listed below.

1. Hole in the Ground Dam
2. Grenada Irrigation District Dam
3. Novy Dam
4. Shasta Water Association Dam
5. Norman Fiock Dam.

In addition to the five dams evaluated above. CES evaluated improvements to two diversions on the Little Shasta River. These diversions included the following:

1. The Hart Diversion
2. The Blair Smith Diversion.

2.0 BACKGROUND

The Shasta River flows through the Shasta Valley and originates in the Eddy Mountains. The river flows for approximately 50 miles and empties into the Klamath River. As the River flows through the valley, it is fed by several tributaries including, Parks Creek, Big Springs Creek, Little Shasta River, and Yreka Creek (Figure 1).

The Shasta Valley supports significant agricultural operations within and around the local communities. Of the approximately 507,000 acres, about 28% or 141,000 acres are irrigatable, and about 52,000 acres are actually irrigated. The Shasta River provides approximately 90% of the water used to support these activities (CDFG, 1997).

Aside from Dwinnell Dam (Lake Shastina), which stores approximately 50,000 acre-feet of water, several smaller irrigation dams and water diversions exists along the Shasta River. Concern has been raised over the impact these dams may have on the water quality of the Shasta

River relative to fall chinook and Coho salmon, as well as fall and winter-run steelhead. In addition, many of these dams and diversions do not provide adequate fish protection relative to passage and screening.

2.1 Geology

The Shasta River Valley is bordered on the east by the Cascade Range and on the west by the Klamath Mountains. Rugged topography and chains of volcanic cones characterize the Cascade Range. Bedrock consists of thick layers of sandstone, graywacke, shales, and basalt. These formations are overlain by alluvium composed of sand, gravel, clays deposited by streams. The majority of the formations are water bearing (DWR, 1986).

The Klamath Mountains were developed by stream erosion of an uplifted plateau. Bedrock consists of schist, greenstone, consolidated sedimentary rocks, and intrusive rocks ranging from granodiorite to serpentine. There are no major faults of recent origin located in the Shasta River Valley.

2.2 Hydrology

The Shasta River valley receives less precipitation than many of the surrounding areas. Much of the precipitation brought from the Pacific Ocean is deposited in the coastal mountains. Typical annual precipitation for the Shasta River valley is on the order of 10 inches. The climate in the region is typically dry in the summer and wet in the winter. About 75 percent of the annual precipitation falls between October and March (DWR, 1986).

A USGS stream gauge on the Shasta River is located near the Town of Yreka approximately 0.5 miles above the confluence of the Klamath River. Data from this gauge indicate that in recent years during the months of April and June flows have averaged 87 cubic feet per second (cfs). Flows during the months of July and August have averaged 28 cfs.

Irrigation diversion has a major effect on overall flows in the Shasta River basin. Local measurements would need to be made to estimate flow at specific locations in the stream since irrigation diversions and confluence with other streams occur all along the river.

3.0 PROJECT SITE DESCRIPTIONS

In this section each of the five sites on the mainstream of the Shasta River and the two sites on the Little Shasta will be described and evaluated. The current condition of each site with regards to fish passage and screening will be discussed. The diversion flows that need to be maintained at each site, as well as operational requirements will be outlined. In addition, deficiencies with regards to fish passage and screening will be noted.

3.1 Hole in the Ground Dam

The Hole in the Ground diversion dam is located on the Emmerson Ranch (Figure 1) and diverts approximately 10 cfs. The dam consists of a concrete check structure with stop logs. The dam has been washed out in previous years and has been reinforced with earthen and wooden dikes. Water is diverted from the dam into a concrete channel for a distance of approximately 350 feet to a pumping station. The pumping station lifts the water approximately 25 feet into an irrigation canal. (See Photos 1 through 4 in Appendix A.)

A wire screen at the beginning of the delivery channel provides screening. The screening is located off the river channel and has no sweeping velocity component. The primary purpose of the screen is to prevent debris from entering the water delivery channel and entering the intake of the pumps. The screening is inadequate for fish protection. Downstream fish passage is provided by an opening in the stop logs near the bottom of the dam; however, .no upstream fish passage is provided.

Water is checked up approximately 5 feet creating an increase in stream surface area above the dam. The channel in the region upstream of the dam has steep side slopes. Consequently, increases in stream depth have little effect on stream surface area. However, when the irrigation pumps are not in operation the depth increases in the channel with a significant water surface area increase.

3.2 Grenada Dam

The Grenada Dam is owned and operated by the Grenada Irrigation District (GID). This diversion also serves the Huesman Ditch Association. Approximately 40 cfs is used by the GID and the Huesman Ditch uses approximately 10 cfs. The dam consists of wooden plank walk boards secured across the stream channel which support vertical slat boards. Water is checked up approximately 4.5 feet. Water is diverted through a concrete structure into an earthen delivery channel. The delivery channel is approximately 15 feet wide.

Diverted water flows approximately 1000 feet to a vertical fixed plate screen with an electrically powered wiper cleaning system. Return flow from the screen drops approximately 4.5 feet over a slat board check back down into the river. Water checked up by the slat boards gravity feeds the Huesman ditch at this point (See Appendix A – Photos 5 through 8).

A fabricated metal fish ladder is located on the north side of the dam. However, the ladder is not submerge correctly and does not meet standard design criteria for this site and sufficient fish passage is not provided. The fish screen is operating well and provides adequate screening where it is located. It appears that sufficient screen surface area is available to accommodate appropriate approach velocities. The off channel diversion however, does not provide safe return passage for fish. The only return pathway is over the spillway of the slat board check, or under the opening of a screw gate (See Photo 8 in Appendix A). The potential for fish injury at this spillway is high. In addition, the long diversion channel creates an environment where fish could be subject to predation or other harm.

3.3 Novy Dam

The Novy Dam provides water for the Novy and Rice ranches. Water is also provided to the Zenkus ranch. The Novy dam diverts approximately 10 cfs through a gravity canal. Water is transported approximately 800 feet to a pond. After the pond, water flows another 800 feet under an access road to the fish screen. The screen is a vertical fixed plate type screen with a paddle wheel brush cleaning system. Fish return flow is provided through a notch in the check boards, which returns to the river through a small gravity ditch.

The Novy dam consists of a steel beam suspended across the river above medium sized rock stacked on the bed of the river. Rock has been placed on either side of the channel to provide stability for and to anchor the steel beam. Water is checked up approximately 3 to 4 feet in the channel by placing slat boards vertically across the channel using the steel beam as a support. The diversion channel is just upstream of the dam (See Appendix A – Photos 9 through 12).

Adequate fish passage is not provided at the diversion dam. Attempts to improve fish passage by the dam owners have been made by removing the check up slate boards to provide a passage notch. As described above, the fish screen for this site is nearly 2,000 feet from the diversion point. This requires the fish to pass through this long channel and the ponded area where predation and other hazards for the fish are increased. The paddle wheel fish screen appears to have sufficient head to operate correctly. However, the fish return flow through the notched check up boards is inadequate.

3.4 Shasta Water Association Dam

The Shasta Water Association (SWA) dam is owned and operated by the Shasta Water Association Irrigation District. This diversion consists of a pumping station and a slat board dam. The dam, shown in Photo 13 and 14 of Appendix A, is located approximately 650 feet down stream of the pump station. Approximately 42 cfs is pumped from the diversion to an irrigation canal. The dam also serves the Kuck ranch through a diversion channel at the dam. The Kuck diversion takes approximately 1.5 cfs (See Appendix A - photo 15). Additionally, there appears to be a very small diversion serving Rizzardo Ranch that maybe abandoned.

A vertical fixed plate screen provides screening for the pump diversion with an electric powered wiper cleaning system just off the river channel. Coarse screening is provided by grates located adjacent to the riverbank. Calculations based on survey data of the site indicate that the screening system has sufficient surface area for the diverted flow. With the screens located off the channel, a fish return passage has been attempted through a pipe inlet that is directed back to the river channel. Due to low grade the distance of the return passage is excessive and is most likely ineffective.

Screening for the Kuck diversion is provided with a vertical fixed plate paddlewheel powered wiper system approximately 150 feet down the diversion channel. Fish return flow is provided through a notch in the stop logs at the screening structure. Providing sufficient head at the paddlewheel screen to power the wiper system and fish return passage are concerns associated with this site.

A large forebay area has developed over the years at the pump station diversion site. The forebay requires dredging every few years to remove settled silt and mud. The dam checks up the water approximately 3.5 feet and creates a significant ponded area through this portion of the river.

The dam itself consists of four concrete piers in the stream channel, which supports horizontal slat boards in 3 side-by-side bays. A steel catwalk also rests on these piers and gives access to the structure (See Appendix A – Photo 13). Fish passage at the dam is provided with a fabricated ladder that is not submerged correctly to provide adequate fish passage.

3.5 Norman Fiock Dam

The Norman Fiock dam provides water to the Antonio ditch, the Fiock Brothers ditch, and the Mariani Ranch (See Appendix A – Photo 16 through 18). Water for the Antonio and Fiock Brothers ditches is provided by gravity flow. Each ditch draws approximately 4 cfs. Approximately 1 cfs is pumped to the Mariani Ranch for a total of 9 cfs diverted at the site. The Antonio ditch begins at the dam site, and proceeds downstream on the west side of the river. The Fiock Brothers diversion is located approximately 800 feet upstream of the dam, while the Mariani ranch pump is located approximately 1,600 feet upstream of the dam, both on the east side of the river. The dam also backs up water for a significant distance, and may create poor water quality conditions, especially in low water years.

The dam has been constructed by stacking large rocks and securing them with concrete. A slat board water elevation control structure has been constructed near the center of the dam. This structure allows release of water from the dam. Water is checked up approximately 3 feet to provide service to the diversions.

Fish passage at the site has been provided with a fabricated ladder. The ladder in not submerged correctly and does not provide adequate passage for fish. Vertical fixed plate screens provide screening for the two gravity diversion with wiper brush type cleaning. In addition, fish return passage through the notched check boards is inadequate.

3.6 Little Shasta River Diversions

The Hart and Blair Smith diversions on the Little Shasta River each consist of a concrete structure spanning the river channel. Check boards are supported in slots in the concrete with steel supports spaced across the structure. Fish passage has been attempted with a Denil style ladder for the Hart Diversion; however, since the ladder is not submerged correctly and does not provide adequate passage. The Blair Smith Diversion does not provide any fish passage.

Screening for each of the diversions has been provided with off channel vertical fixed plate screens with a paddle wheel cleaning system. Return fish passage has been provided with a notch in the check boards and return flow piping. The screening appears to be adequate; however, sufficient head to operate the paddle wheel is could be a concern during low stream flow periods and fish return passage is inadequate.

4.0 SCREENING OPTIONS

Various fish screening methods have been developed to protect adult and juvenile fish at irrigation diversions. The National Marine Fisheries Service (NMFS) and the California

Department of Fish and Game (CDFG) have developed criteria governing the design and installation of screens to protect fisheries. These criteria are provided in Appendix B.

Provided below is a discussion on screening systems and approaches that focus on low cost installation and simple operation. These types of screening systems are most likely to be successful at the five diversion sites evaluated in this report. Typically, more than one of the screening methods described below would be feasible at any give diversion site. A discussion of feasible screening methods for each specific site is presented later in this report.

4.1 Rotary Drum Screens

Rotary drum screens have been widely used in the Pacific Northwest (Nordlund, 1996). These screens have had a good success rate and are widely accepted by regulatory agencies. The screens operate by powering a screened drum that rotates to move debris away from the screen. A typical installation and schematics of a rotary drum screen is shown in Figure 2.

In order for rotary drum screens to function properly, a minimum level of submergence has to be maintained. The best level of submergence is between 70% to 85%. If these screens are submerged over 85%, the potential for fish impingement is increased. This means that the water level at the diversion site needs to be controlled to provide a steady screen submergence. Rotary drum screens do required consistent monitoring and maintenance of side and bottom seals for wear. They also do require a power source for operation and some civil works to secure them in place.

4.2 Pump Intake (pressure backwash) Screens

Pump intake screens are available from several commercial suppliers and come in different configurations. These screens can be placed on the suction side of pumping systems and can be installed in a variety of configurations to meet design and operational requirements. (See Figure 3).

The screen is kept clean with a "pressure backwash" spray bar system. Pressures required for backwash typically ranges from 30 to 100 pounds per square inch (psi) depending on the diversion flow being screened. Backwash flows required are on the order of 20 to 100 gallons per minute (gpm).

Pump intake screens for irrigation diversion systems typically required an additional pump to provide the backwash pressure since diversion pump pressures are usually lower than what is needed to provide backwash pressure. Some form of power (i.e. electrical or diesel) must be provided to operate these screens. These systems are effective, when installed according to manufacturer recommendations.

4.3 Vertical Fixed Plate Screens

Vertical fixed plate screens are also widely used in the Pacific Northwest (Nordlund, 1996). This type of screen is currently used at each of the diversion sites evaluated in this report. The mechanical cleaning system for these screens typically consists of a brush system that is moved back and forth across the screen. When this type of cleaning system is used the screen is called a gang wiper screen. This type of screen and cleaning system is shown in Figure 4.

Vertical fixed plate screens can also be cleaned with a pressure backwash system or an air burst system. A well-designed brush cleaning system will produce small eddies behind the brush as it travels the length of the screen which suspends debris until is has passed the downstream end.

When vertical fixed plate screens are located on the stream bank, provisions for protecting the cleaning brushes and screen from icing and large floating debris damage must be included in the design. If power is not available to operate a brush system, a paddle wheel or solar panel may be used to power the screen cleaning device.

4.4 Flat Plate Screens

Flat plate screens have been designed in a variety of configurations. These screens can be installed horizontally or at an angle. Flat plate screens generally rely on the sweeping velocity of the water flowing past the screen to keep the majority of the screen surface debris free. Flat plate screens have been installed with self-cleaning systems such as airburst or pressure backwash.

The invisible weir screen is a horizontal flat plate screen constructed in the stream channel. Grade control is required for this type of screen to ensure that a sufficient depth of water is maintained over the screen for fish protection. Water grade control can be obtained using rock or concrete weirs (See Section 5.2). The inverted weir screen should only be used in streams where a high gradient exists to ensure that sufficient sweeping velocities across the screen can be maintained. Figure 5 shows the installation of an invisible weir flat plate screen.

If conditions are right, these screens can be installed without self-cleaning and would have no moving parts and therefore minimal maintenance. However, screens without some type of self-cleaning have not been approved by NMFS.

5.0 FISH PASSAGE

Irrigation diversion dams create a barrier to fish passage when proper passage devices have not been provided. Various approaches to fish passage are available. The methods most appropriate for the Shasta River diversion dams will be discussed here. These include pool-weir-chute fishways, fish passable weirs, and water control structures. A Denil style fishway is another common type of fish way. These fishways often require attraction flow accommodations to work correctly on large steams and rivers. This type of ladder has been mentioned in this study since it may be installed at some of the sites to improve fish passage. However, these fishways will most likely not provide an adequate level of fish passage and are not recommended for a long-term solution.

5.1 Pool - Weir - Chute Fishways

Pool – weir – chute fishways essentially consist of a series of weirs and pools through which the fish can swim or jump. These fishways can be incorporated into a water control structure or they can be installed independently.

Pool – weir – chute fishways operate in a plunging flow regime at low flows but have a more streaming flow regime during high flows. The weirs are constructed in a baffle wall that is slanted upward to the outside wall of the ladder (BPA, 1996, also Figure 6B Baffle Section View). These slanted baffles provide fish resting areas during high flows along the outside walls. The plunging flow regime provide passage for leaping fish while the streaming flow regime provides passage for other fish that prefer not to leap. At lower flows when the ladder is operating in a plunging flow regime, passage for fish that prefer not to leap can be provided with ports and openings at the base of the baffle walls (WDFW, 2000). However, a minimum flow must be maintained through the ladder when these openings are used. Details of a typical pool – weir – chute fishway are shown in Figure 6.

This type of fishway provides fish passage for a wider range of flows and can be designed to accommodate all the flow in a stream the size of the Shasta River. These structures can be complicated to construct however.

5.2 Fish Passable Weirs

Fish passable weirs can be constructed out of a variety of materials including timber, concrete, or rock. At low flows a notch in the center of the weir provides fish passage. The notches should be designed and constructed to provide a minimum water depth through the notch during low flow. In addition, if the weir is constructed out of rock, the weir will typically require sheet piling or extremely tight fitting of rock during construction to encourage sealing to ensure that at low flows water passes through the notch and not through the coarse rock (NRCS, 2000). Fish passable weirs can be used in series to step the water elevation in a stream and/or provide grade control. When weirs are installed in series attention has to be paid to spacing so that the scour of one weir does not undermine the next downstream weir.

These weirs are often used down stream of other fish passage structures to provide the grade control required to ensure the passage structures work correctly. Installation details for a fish passable rock weir is shown in Figure 7.

5.3 Denil Fish Ladders

Denil fish ladders are typically pre-manufactured from concrete or aluminum; however, alternative materials can be used if required. They are typically narrow chutes or flumes with baffles to control internal flow for fish passage. Denil fish ladders work well for both juvenile and adult salmonids. On the east coast, there has been no problem passing all age classes of salmonids and warm water species. Denil fishways do not accommodate a wide variety of flows and can be limited in there applicability (BPA, 1996). Denil style fishways do not provide resting areas for fish. This means that the fish need to move all the way through the ladder in a single swimming burst. Fish resting pools should be provided when the ladder is longer than 30 to 50 feet (See Figure 8).

6.0 WATER CONTROL STRUCTURES

A water control structure is a structure that has been designed to provide water elevation control for irrigation diversion as well as fish screening and passage. These structures can be configured as required for the conditions at the diversion site. The structures typically will include stop logs for water control and fish passage.

Figure 9 shows a water control structure that can be installed in the stream channel and provides fish passage and screening. This type of structure can be adapted to many diversion sites when specific site civil work is designed and constructed.

7.0 DIVERSION DAM SITE IMPROVEMENT ALTERNATIVES

In the following sections, selected site improvement alternatives for the five diversion dams on the Shasta River will be evaluated. The alternatives evaluated in these sections focus on making use of the fish passage and screening methods discussed previously in this report. However, it must be pointed out that additional options exist for improvement of fish passage and screening that are not outlined in each of the sections.

For each of the sites the option of doing nothing could be considered. Since there currently is no regulatory mandate for improvements to the diversion sites this is certainly an option. However, it is unclear how long this will remain an option without regulatory intervention. It should also be noted that funding for many of these types of projects is becoming more readily available. It would be in the best interest of the landowners to take advantage of this opportunity to make needed improvements. In addition, improvements to water quality and habitat of endangered species (i.e. Coho) are also important considerations. Total maximum daily loads (TMDLs) have been established for the Shasta River and must be attained by 2005. It must be noted that implementation of most of these options will likely help achieve the TMDL requirements and increase endangered species habitat; however, not all the options outlined in this report will.

CES has presented options for each of the sites that will adequately address both fish passage and screening deficiencies. Most of these options can be implemented in part, however, this will not address both fish passage and screening and could result in further scrutiny from regulatory agencies in the future.

The fish passage recommended for each site will provide both up and downstream passage for coho, steelhead, and chinook. Passage for both adult and juvenile fish will be provided with the fishways proposed.

Cost estimates for the alternatives evaluated below have been provided in Tables 2 through 19. The estimates assume a contractor will perform the work. Further evaluation of these costs will need to be done if work is to be provided by landowners. The accuracy of the costs provided below should be considered to be plus 50% to minus 30%. It should also be understood that these costs are presented in 2001 dollars and will increase with future inflation. Approximate cost estimates for annual pumping power costs were calculated with the assumption that the pumps would operate 6 months annually with 64% pump efficiency and 85% motor efficiency.

All instream structures will be designed to survive 1500 cfs peak flow or the 100 year flood event whichever is greater. This engineering design will allow these structures to be durable, accommodate fluctuating seasonal flows and be economical.

7.1 Hole in the Ground Dam

At this site various options were evaluated to improve fish passage and screening and to evaluate the possibility of lowering the water elevation at the diversion. CES considered the possibility of moving the diversion upstream and using an invisible weir screening system so that pumping would not be required. However, after reviewing site conditions upstream a suitable channel section with sufficiently fast moving water could not be found. Therefore this screening option was not considered further.

Also, moving the diversion upstream using a similar check structure would not provide any benefit and the considerable length of piping required to bring the water to the irrigation canal would be much more costly than other options. Therefore this option was not considered further.

CES evaluated three options for this site.

1. Do nothing, maintain existing diversion with no passage or screening improvements.

2. Replace the existing check structure with a pool weir chute check structure for fish passage and modify the open channel water delivery ditch to allow a lower water depth and install adequate fish screening at the entrance to the channel.

3. Replace the existing check structure with a pool weir chute check structure for fish passage, relocate the pumps to be adjacent to the check structure, and replace the open channel ditch with piping.

These options are discussed below. A layout of Options 2 and 3 are shown in Figure 10. A summary of all the options is provided in Table 2.

Option 1 – For this option, no action would be taken at the dam site. The benefit to this option would be no capital cost for improvement. The system currently functions and provides water to the irrigation canal.

With this option no improvement to fish passage and screening would be attempted. The major drawback to this option is the potential for regulatory scrutiny and action in the future. This could lead to action mandated by a regulatory agency and reduce available options. The landowner may also loose control of water diversion activities under this option.

In addition, doing nothing at this site could lead to the need for replacement of the existing structure after a failure. The current structure is very unstable and is likely to fail without some reinforcement. Under this option the opportunity for cost share for making improvements to the dam itself would not be available.

Option 2 – A pool weir chute check structure as described in Section 5.1 would be installed in place of the existing structure. The structure would be designed to allow the entire stream flow to pass over the fish ladder section eliminating the concern over fish attraction flow.

The pool weir chute fish ladder recommended for this site will provide both up and downstream passage for coho, steelhead, and chinook. Passage for both adult and juvenile fish will be provided with the fish ladder proposed.

Water at the diversion is checked approximately 5 feet to deliver flow through the ditch to the lift pumps. In order to lower the water elevation at the site and continue to deliver the same amount of water, the ditch channel will have to be modified. Either lowering the bottom of the channel and/or widening the channel can do this. Survey data indicates that the ditch bottom could be lowered approximately 2.3 feet without affecting the bottom of the stream channel. This would allow the water at the diversion to be checked up 2.3 feet less than what it is currently. By widening the channel the check elevation would approximately be lowered by another foot.

To provide adequate fish screening, a rotary drum screen or vertical traveling screen would be installed at the entrance of the water delivery ditch to keep fish in the main channel and eliminate the need for fish return flows. Costs associated with Option 2 are shown in Table 3.

Option 3 – With this option a pool weir chute check structure would be installed to replace the existing structure as described in Option 2. Under this option the lift pumps would be relocated adjacent to the check structure. The pumps would be installed with pressure backwash screens piped directly to the suction cans on the pumps. An additional pump would need to be provided to operate the pressure backwash screen since a higher pressure is required to run the screen than to lift water to the irrigation canal.

The open channel ditch would be abandoned and replaced with piping from the discharge side of the pumps. This would eliminate maintenance and cleaning at the entrance to the ditch. Costs associated with Option 3 are shown in Table 4.

7.2 Grenada Irrigation District Dam

When reviewing options for the Grenada dam site special consideration was given to the following:

1. Elimination of the long diversion channel and fish return over the high check drop;
2. The high volume of water diverted (approximately 50cfs); and
3. The large drop in elevation from the screening and pump intake area back to the stream channel.

Because of the high volume of water being diverted at this site, pressure backwash, rotary drum, and vertical traveling screens were not considered. At these high flows the infrastructure required for these screening options make them unattractive economically and from a maintenance point of view. The screening options considered for this site are variations of the vertical fixed plate type of screen. The invisible weir was also not considered here due to the volume of water being diverted and the low gradient upstream of the diversion site.

The possibility of moving the diversion structure farther upstream and piping water to the pump station area was considered. It was hoped that this would allow a lower checked up water elevation in the stream. However, survey data indicated that the upstream distance required to provide adequate head would result in long and costly piping systems. It was concluded that the same benefit could be obtained more economically from Option 2 described below.

After a review of site conditions and diversion requirements, CES performed an evaluation of the following three options. Options 2 and 3 are shown in Figure 11. All three options are summarized in Table 5.

1. Do nothing, maintain existing diversion with no passage or screening improvements.

2. Replacement of the existing diversion dam with a pool-weir-chute water control structure for fish passage, relocation of the screening structure from near the pump station to the diversion area, and maintain the existing checked up water elevation.

3. Replacement of the existing diversion dam with a pool-weir-chute control structure for fish passage, relocation of the screening structure from near the pump station to the diversion area, and lower the system approximately 3 to 4 feet to eliminate ponded area above the diversion. Make modifications to the existing pump station and Huesman ditch diversion to accommodate the lower water surface elevation (i.e. pumping modifications).

Option 1 – For this option, no action would be taken at the dam site. The benefit to this option would be no capital cost for improvement. The system currently functions and provides water to the irrigation canal.

With this option no improvement to fish passage and screening would be attempted. The major drawback to this option is the potential for regulatory scrutiny and action in the future. This could lead to action mandated by a regulatory agency and reduce available options. The landowner may also loose control of water diversion activities under this option.

Option 2 – Under this option a pool-weir-chute check structure would be installed in place of the existing diversion dam. The structure would be designed to provided permanent fish passage at a wide range of flows. The fish ladder will provide both up and downstream passage for coho, steelhead, and chinook. Passage for both adult and juvenile fish will be provided with the fish ladder proposed.

The existing screening structure would be relocated near the existing diversion area. A screening structure using a vertical fixed plate screen with either a gang wipe or pressure backwash for self-cleaning would be used. Relocation of the screen will keep fish in the stream channel and eliminate the need for fish return flow. In addition fish will be kept out of the water delivery channel and eliminate the possibility of predation in this area.

Under this option the checked up water surface elevation would be maintained and no modifications to the existing pump station and Huesman ditch diversion would be needed. However, this would maintain the ponded area above the diversion and not reduce water surface area. Costs associated with Option 2 are found in Table 6.

Option 3 – Under this option the pool-weir-chute and vertical fixed plate screen structures would be installed to replace the existing diversion dam and screen as described in Option 2. However, with this option the check structure and screen would be lowered to reduce ponded area above the diversion.

Lowering the check structure and screen would require modifications to the existing pump station and Huesman ditch diversion. Survey data indicate that the channel bottom at the existing fish screen and the existing diversion dam differ by only 0.26 feet. This means that in order to lower the water elevation at the diversion and maintain sufficient submergence on the suction side of the pumps, the elevation of the diversion channel bottom at the pumps, as well as the pump intake would need to be lowered. Lowering the pump intakes could affect pumping capacity and efficiency. However, due the age of the pumps it is be difficult to predict pump performance without field testing for a specific head verses discharge pump relationship.

Lowering the checked water elevation could affect pumping capacity. However, due to the age of the pumps it will be difficult to predict this affect without performing head verses discharge testing to develop a curve for the pumps. CES reviewed pumps curves for pumps that could meet the discharge and head requirements for this diversion to assess what the affect of lowering the water elevation 3 to 4 feet would have on capacity. This review indicated that lowering the intake level this amount on the pumps reviewed would reduce flow by approximately 350 gallons per minute or approximately 4.0 %.

The pump parameter that is affected by lowering the intake elevation is the net positive suction head. How much this parameter will be affected depends on the design of the pump casing and intake as well as other factors. Discussions with experienced pump suppliers and designers indicate that the split case centrifugal pumps currently being used should be nearly as efficient as new pumps. However, as mentioned above, without specific testing on the existing pumps it will be difficult to predict any loss in capacity from lowering water intake levels with acceptable accuracy.

Lowering the channel bottom at the pumps will also require providing pumping to lift water into the Huesman diversion. The Huesman ditch is currently fed by gravity. Additional pumping could easily be installed in the existing pump station for this purpose. Relocating pumping for the Huesman ditch close to the point of use, with either a single pump or several individual pumps serving each user, would improve water usage efficiency for the ditch. Pumping costs could be offset by reduced ditch maintenance costs. The availability of power, the preference of the Huesman Ditch Association members and access for maintenance would need to be evaluated.

During site investigations at this diversion it was determined that a pumping efficiency analysis should be done for the GID pump station. Due to the age of the existing pumps, replacement of the pump station with an upgraded system could prove to be economically beneficial for the

GID. An evaluation of reduced power costs due to improved pumping efficiency and the period required for these savings to pay for capital costs associated with a pump station upgrade could easily be performed. Costs associated with Option 3 are found in Table 7.

7.3 Novy Dam

The most significant improvement for fish screening at the Novy Dam Site can be made by relocation of the screening system to the mouth of the diversion. This will require that power be provided for screen cleaning since sufficient head for the paddle wheel system would not be available. However, relocation of the screen will eliminate the potential for fish predation through the long channel and ponded area. This will also eliminate the problem with fish return flows and passage.

Survey data at this site indicate that the water is check up approximately 3 feet. The water depth above the dam is approximately 5 feet. The water surface at this dam could be lowered approximately 3 feet if pumping is provided with the screening modifications. Electrical power and controls could be provided for the screen cleaning and pumping simultaneously.

Improvements for fish passage can be made by incorporating a pool-weir-chute fish ladder into a water control structure. Water elevation control would be provided with the ladder stop logs. An economical pool-weir-chute ladder that passes all the stream flow could be provided at this site since the water is not check up more than 3.0 feet.

Layouts of Options 2 through 4 are shown in Figure 12. A summary of the options is provided in Table 8. Options considered for this site include the following.

Option 1 - This option is the no action option. With this option no improvements at the site would be made with respect to fish passage and screening. The benefit to this option would be no capital cost for improvement. The system currently functions and provides water to the irrigation canal.

The major drawback to this option is the potential for regulatory scrutiny and action in the future. This could lead to action mandated by a regulatory agency and reduce available options. The landowner may also loose control of water diversion activities under this option.

Option 2 – For this option, the existing dam would be replaced with a water control structure with a pool-weir-chute fish ladder as described in Section 5.1. The structure would be designed to provided permanent fish passage at a wide range of flows. The fish ladder will provide both up and downstream passage for coho, steelhead, and chinook. Passage for both adult and juvenile fish will be provided with the fish ladder proposed.

The existing screening system would be replaced with a rotary drum. The screening system would be relocated to the mouth of the diversion channel. Pumping would be provided so that the water surface elevation could be lowered. Power would need to be provided for the screening. Power is available approximately one half mile away. Costs associated with Option 2 can be seen in Table 9.

Option 3 – This option would consist of making only the fish passage improvements by providing the water control structure with the pool-weir-chute fish ladder. Under this option the water surface elevation could not be lowered since the screening system modifications and pumping would not be provided. Costs associated with Option 3 can be seen in Table 10.

Options 4 – This option would provide only the screening improvements. Fish passage would not be improved and the water control structure would not be provided. The water surface elevations could be lowered if pumping is provided by adjustment of the slate board on the existing dam. Cost associated with Option 4 are shown in Table 11.

7.4 Shasta Water Association Dam

Initial review of this site clearly indicated that one of the greatest opportunities to improve conditions for fish is to eliminate excessive stream surface area by moving the existing dam upstream close to the pump station. Doing this will require special attention to ensure that the Kuck diversion can continue to be served.

As with the Grenada dam site the options for improving fish passage and screening at this site are limited due to the large diversion volumes required (43.5 cfs). Screening options considered at this site included variations on the vertical fixed plate screen style. Options for improving fish passage can be incorporated into a water control structure that will replace the existing slat board dam. The water control structure design will ensure that flexible but dependable water elevation control for fish screening and pumping intake is maintained. Due to the growing desire to recapture water for instream flows, and to allow for the future operational flexibility, variable delivery pumps should be evaluated for this site.

A layout of Option 2 and 3 is shown in Figure 13. A summary of the options is provided in Table 12. Improvement options evaluated are described below.

Option 1 – Under this option no action would be taken to improve fish passage or screening or potential water quality problems, at the site. There would be no capital costs associated with improvements. However, no channel improvements would be made to eliminate dredging operations. The system currently functions and provides water to the irrigation canal.

The major drawback to this option is the potential for regulatory scrutiny and action in the future. This could lead to action mandated by a regulatory agency and reduce available options. The landowner may also loose control of water diversion activities under this option.

Option 2 – This option would include replacement of the existing slat board dam with a water control structure with permanent fish passage. The structure would be designed to provided fish passage at a wide range of flows. The fish ladder will provide both up and downstream passage for coho, steelhead, and chinook. Passage for both adult and juvenile fish will be provided with the fish ladder proposed.

The water control structure would be installed near the existing pump station. The existing vertical flat plate screen would be maintained with minor upgrades. This system would operate at the current water level. Water supply for the Kuck and Rizzardo diversion would be screened at the water control structure and gravity piped to the existing ditch.

By moving the water control structure upstream to the pump station area, the existing fish return flow piping could be improved. The improvements would include increasing the size of the piping and relocating the outlet farther upstream to reduce the return flow distance.

This option would also include upstream channel modifications to eliminate the need for dredging the forebay area and provide additional stability for a new water control structure. Costs associated with Option 2 are shown in Table 13.

Option 3 – This option would include replacement of the existing slat board dam with a water control structure with permanent fish passage as described in Option 1. The structure would be installed near the existing pump station.

Under this option, additional efforts would be made to decrease stream surface area by lowering the checked up water elevation. Water at the site is currently checked up approximately 3.5 feet. Based on survey data at the site, lowering the water elevation would require a longer vertical fixed plate screen to maintain adequate screen area. A longer screen would not fit in the existing screen bay and would have to be moved out parallel to the stream channel and bank. The screen support structure would be incorporated in the water control structure. This option would eliminate the need for fish return flow piping. Survey data indicates that the checked water elevation could be lowered approximately 2 feet.

This option would require that water supply for the Kuck and Rizzardo diversions be pumped and piped to the existing ditch. Pumping could be provided at the existing pump station. Piping could be installed under the stream during construction of the water control structure.

Lowering the checked water elevation could affect pumping capacity. However, due to the age of the pumps it will be difficult to predict this affect without performing head verses discharge testing to develop a curve for the pumps. CES reviewed pumps curves for pumps that could meet the discharge and head requirements for this diversion to assess what the affect of lowering the water elevation 2 feet would have on capacity. This review indicated that lowering the intake level this amount on the pumps reviewed would reduce flow by approximately 350 gallons per minute or approximately 4.0 %.

The pump parameter that is affected by lowering the intake elevation is the net positive suction head. How much this parameter will be affected depends on the design of the pump casing and intake as well as other factors. Discussions with experienced pump suppliers and designers indicate that the old Worthington split case centrifugal pumps currently being used should be nearly as efficient as new pumps. However, as mentioned above, without specific testing on the existing pumps it will be difficult to predict any loss in capacity from lowering water intake levels with acceptable accuracy.

As with Option 1, upstream channel modification would be made to eliminate the requirement for dredging and to provide structural stability for the water control structure. Costs associated with Option 3 are shown in Table 14.

During our site visits to this site, the possibility of converting the irrigation canals to piping to improve water delivery efficiency was discussed. Evaluation of this and other possibilities within the Shasta Water Association should be taken to improve efficiency of operations as soon as possible to assure that a well – planned and comprehensive approach to all water issues is taken, particularly in light of the large quantity of water pumped by the SWA.

7.5 Norman Fiock Dam

The Norman Fiock Dam site is somewhat different than the other sites that have been evaluated during this study. This dam provides water to three relatively low volume (1 to 5 cfs) irrigation diversions. The diversion points for each of these diversions are also relatively far from each other.

Further reduction in water levels can only be achieved if pumping for the users of Antonio and Fiock Brothers ditch is provided. It is assumed that the pumping provided at the Mariani diversion is adequate for a somewhat reduced water surface level.

Water quality, at this site, is frequently the worst found in the Shasta River. Water quality data suggests that dissolved oxygen levels sometimes fall below the limit considered to be lethal for salmoids. Lowering water levels by providing pumping will partially address this problem.

While fish screening is provided for the two gravity diversions with a vertical fixed plate screen with paddle wheel cleaning, observation indicated that there is insufficient head to operate the cleaning system adequately. Increasing the head on these paddle wheels would require a higher water elevation in the system, which would in turn increase surface water area. Power for operating the paddle wheels could be supplemented with solar power or by tapping into local power lines.

Survey data indicates that the water is checked up approximately 3.0 feet to feed the irrigation ditch diversion. The water depth above the dam is approximately 4.0 feet. Through modifications of the existing dam and installation of grade control structures (rock weirs) at each of the diversion points, the opportunity to lower the water surface elevation by 2 to 3 feet is possible.

The options for improvement of fish passage and screening that were evaluated at this site are described below. Figure 14 shows a layout of options 2 through 4. A summary of each option is shown in Table 18.

Option 1 **-** Under this option no action would be taken to improve water quality, fish passage or screening at the site. There would be no capital costs associated with improvements. The system currently functions reliably and provides water to the irrigators.

The major drawback to this option is the potential for regulatory scrutiny and action in the future. This could lead to action mandated by a regulatory agency and reduce available options. The landowner may also loose control of water diversion activities under this option.

Option 2 – This Option includes modifications to the existing dam to include a pool-weir-chute fish ladder. The ladder would be designed to provided fish passage at a wide range of flows. The fish ladder will provide both up and downstream passage for coho, steelhead, and chinook. Passage for both adult and juvenile fish will be provided with the fish ladder proposed. The ladder could serve as a grade control or check structure as well as provide fish passage. This would allow the system to operate at varying water elevations and increase operational flexibility.

Adequate fish screening would be provided by relocation of the existing screens to the channel banks. This will eliminate the need for fish return flows and passage. The screens would be replaced with either vertical traveling or rotary drum screens depending on users preference. For each of these screens electrical power would need to be provided. Costs associated with Option 2 are shown in Table 16.

Option 3 – A third Option for this site would be replacement of the existing dam with a pool-weir-chute passage/ check structure. The new structure would be oriented and aligned in the stream channel such that the scouring of the downstream banks currently occurring in the channel would be eliminated. This would help to stabilize the channel banks downs stream of the existing dam.

As with Option 2, the screening for the diversion would be relocated to the river channel. With this option pumping would be provided in conjunction with the screening. This would allow the stream water elevation to be lowered by 2 to 3 feet. Power would need to be provided for the two additional pumps. Grade control weirs would be installed near each diversion to step down the water elevation. The weirs would be fish passable rock weirs. Costs associated with Option 3 are shown in Table 17.

Option 4 – Option 4 would include removal of the existing dam. Water for each of the properties served by the Antonio and Fiock Brothers ditches would be supplied with a pumping system located near the point of use as shown in Figure 15. Individual pumps with adequate fish screening would be provided for each irrigator at these new diversion locations. The locations shown on Figure 15 are approximate. Actual locations should minimize pumping distances while ensuring water delivery to all areas desired. For this option grade control weirs or barbs would have to be provided at each diversion to ensure proper submergence for the pump intakes. Under this option the water elevation would be lowered approximately 3 feet. This option would eliminate a significant amount of ditch maintenance; in addition water delivery to the point of use would be more efficient.

Other issues discussed at this site included the possibility of piping diversion water to the point of use to improve water usage efficiency and providing a central irrigation pump station at a single dam to service each irrigation ditch. The dam would have fish passage while the pumping stations would be provided with adequate fish screening. The potential loss of sub irrigation to acreage adjacent to the ditches must be evaluated if water is piped or if the point of diversion is moved closer to the point of use. This could create additional water requirements on some of this acreage. Costs associated with Option 4 are shown in Table 18. This may call for further detailed studies and working with irrigators on each ranch to identify ways to modify individual ranch's irrigation practices.

7.6 Little Shasta River Diversions

Surveys need to be performed for the Little Shasta River sites. Site investigations provide sufficient information to make recommendations for improvement of fish passage and screening. These recommendations are described below.

Hart and Blair Smith Diversions - Site conditions at the Hart and Blair Smith diversion are different in that there is a relatively high stream gradient and velocity. At these locations the Little Shasta has a low, fine sediment load when compared to the diversion location on the Shasta River. These site conditions right for the use of a flat plate invisible weir type screen as described in Section 4.4.

CES recommends installation of a flat plate invisible weir type screen at these locations. This will eliminate the need for off channel screening and fish return flows. The existing structure would be removed and replaced with the invisible weir. Fish passable grade control weirs will be installed with each screening system to ensure that an acceptable level of water is maintained over the screen surface.

CES recommends installing the invisible weir system with an air burst cleaning system. This system will include a electric powered air compressor with a battery operated timer and control mechanism. This system will periodically send a burst of air through the screen surface to remove debris. Cost estimates for improvements at the Hart and Blair Smith Diversions are provided in Table 19.

8.0 CONCLUSION AND RECOMMENDATIONS

The recommendations provided above will provide permanent fish passage and adequate screening for each of the diversion sites evaluated. In addition at least one option described for each site will lower water elevations and reduce water surface area to minimize stream temperature increases. Implementation of these recommendations can be funded in a large part with Federal and State grant dollars. Communication with local landowners and those involved with each proposed project will be the key to successful implementation of these projects. Implementation of these projects will improve screening for over 150 cfs of diversion water and eliminate fish passage barriers and/or screening problems at 5 locations along the Shasta River and 2 locations along the Little Shasta River.

REFERENCES

California Department of Fish and Game, July 1996. A Biological Needs Assessment for Anadromous Fish in the Shasta River Siskiyou County, California

State of California Department of Water Resources, February 1986. Shasta/Klamath Rivers Water Quality Study.

Bryan Nordlund, National Marine Fisheries Service, June 1996. Designing Fish Screens for Fish Protection at Water Diversions.

Bonneville Power Administration, 1996. Upstream Fish Passage Technologies: How Well Do They Work?

Washington Department of Fish and Wildlife, April 2000. Fishway Guidelines for Washington State.

National Resource Conservation Service, March 2000. Design of Rock Weirs.

TABLES

Table 1. Site and Water Users Summary Information

Site	Water Users	Diversion Flow (CFS)
Hole In The Ground Dam	Emmerson Ranches	10
Grenada Dam	Grenada Irrigation District	40
	Huesman (Rice, Novy, Marion, Nocoletti, Root)	10
Novy Dam	Novy, Rice Ranch, Zenkus	15
Shasta Water Association Dam	Shasta Water Association	42
	Kuck Ranch	1
	Rizzardo Ranch	0.5
	Banhart Ranch	
Norman Fiock Dam	Antonio Ditch	4
	Fiock Brothers Ditch	4
	Mariani Ranch	1
	Himmel	
	Spearin	

Table 2. Hole in the Ground Dam Improvement Option Summary

Option	Description	Improves Passage	Improves Screening	Lowers Water Level	Estimated Capital Costs	Estimated Annual Operating Costs	Comments
Option 1	Do nothing, no modification or improvement	No	No	No	$0	$0	Leaves site open to future regulatory scrutiny and/or action. Existing Structure has high potential for washout or failure.
Option 2	Replacement of existing structure with pool-weir-chute check structure. Modify open channel water delivery ditch for lower water elevation. Install adequate fish screening at the ditch entrance.	Yes	Yes	Yes (approx 2.5 feet)	$217,000	$1,400	Pool-weir-chute will provide both upstream and downstream passage for all ages. Assume use of existing pumps. Fish screening would be vertical traveling or rotary drum.
Option 3	Replacement of existing structure with pool-weir-chute check structure. Relocate pumps close to check structure and provide adequate fish screening. Replace open channel ditch with piping.	Yes	Yes	Yes (approx 3.0 feet)	$251,000	$1,700	Pool-weir-chute will provide both upstream and downstream passage for all ages. Assume use of existing pumps. Fish screening would be pressure backwash system.

Table 3. Hole in the Ground Dam - Option 2
Preliminary Cost Estimate - November 2001 (+50% / -30% accuracy)

Bid Item	Description	Quantity	Unit of Measure	Unit Costs	Total Amount Quantity x Unit Price
1	Mobilization and Demobilization	1	JOB	15,000	$15,000
2	Demolition of Existing Dam	1	JOB	5,000	$5,000
3	Structural Concrete	50	CY	850	$42,500
4	Excavation/Earthfill	800	CY	20.0	$16,000
5	Rock Riprap	100	CY	55.0	$5,500
6	Modification to Water Delivery Channel	350	LF	15	$5,250
7	Stream Water Control	1	JOB	20,000	$20,000
8	Sheet Piling	320	SF	20.0	$6,400
9	Metal and Fabrication	1	JOB	5,000.0	$5,000
10	Electrical Supply	1	LS	5,000	$5,000
11	Fish Screening	1	LS	25,000	$25,000
12	Site Work	1	LS	10,000	$10,000
	Total Construction Costs				**$160,650**
	Administration, Engineering, Legal, Contingency (35%)				**$56,228**
	Total Estimated Project Cost				**$216,878**

Table 4. Hole in the Ground - Option 3
Preliminary Cost Estimate - November 2001 (+50% / -30% accuracy)

Bid Item	Description	Quantity	Unit of Measure	Unit Costs	Total Amount Quantity x Unit Price
1	Mobilization and Demobilization	1	JOB	18,000	$18,000
2	Demolition of Existing Dam	1	JOB	5,000	$5,000
3	Structural Concrete	50	CY	850	$42,500
4	Excavation/Earthfill	800	CY	20.0	$16,000
5	Rock Riprap	100	CY	55.0	$5,500
6	Piping Extension	350	LF	35	$12,250
7	Stream Water Control	1	JOB	20,000	$20,000
8	Sheet Piling	320	SF	20.0	$6,400
9	Metal and Fabrication	1	JOB	5,000.0	$5,000
10	Electrical Supply	1	LS	8,000	$8,000
11	Fish Screening	1	LS	20,000	$20,000
12	Pressure Backwash Pump	1	LS	5,000	$5,000
13	Pumping Vault	1	LS	12,000	$12,000
14	Site Work	1	LS	10,000	$10,000
	Total Construction Costs				**$185,650**
	Administration, Engineering, Legal, Contingency (35%)				**$64,978**
	Total Estimated Project Cost				**$250,628**

Table 5. Grenada Dam Improvement Option Summary

Option	Description	Improves Passage	Improves Screening	Lowers Water Level	Estimated Capital Costs	Estimated Annual Operating Costs	Comments
Option 1	Do nothing, no modification or improvement	No	No	No	$0	$0	Leaves site open to future regulatory scrutiny and/or action.
Option 2	Replace existing dam with a pool-weir-chute check structure. Relocate screen structure to diversion area.Maintain existing water elevation with no modifications to the pump station intakes	Yes	Yes	No	$337,000	$0	Pool-weir-chute will provide both upstream and downstream passage for all ages. Will eliminate long delivery channel and need for fish return passage. Fish screening will be vertical fixed plate.
Option 3	Replace existing dam with a pool-weir-chute check structure with lower water elevation. Relocate screen structure to diversion area. Modify pump station intakes to compensate for a lower water surface elevation. Provide pumping for the Huesman ditch.	Yes	Yes	Yes (approx 3 to 4 feet)	$405,000	$7,600	Pool-weir-chute will provide both upstream and downstream passage for all ages. Will eliminate long delivery channel and need for fish return passage. Could affect pumping capacity slightly. Huesman ditch pump could be located down stream near the point of use. Fish screening will be vertical fixed plate.

Table 6. Grenada Dam - Option 2
Preliminary Cost Estimate - November 2001 (+50% / -30% accuracy)

Bid Item	Description	Quantity	Unit of Measure	Unit Costs	Total Amount Quantity x Unit Price
1	Mobilization and Demobilization	1	JOB	24,000	$24,000
2	Demolition of Existing Dam	1	JOB	7,000	$7,000
3	Structural Concrete	85	CY	850	$72,250
4	Excavation/Earthfill	1,200	CY	20.0	$24,000
5	Rock Riprap	200	CY	55.0	$11,000
6	Stream Water Control	1	JOB	30,000	$30,000
7	Sheet Piling	1,120	SF	20.0	$22,400
8	Metal and Fabrication	1	JOB	10,000	$10,000
9	Electrical Supply	1	LS	4,000	$4,000
10	Fish Screening	1	LS	15,000	$15,000
11	Site Work	1	LS	30,000	$30,000
	Total Construction Costs				**$249,650**
	Administration, Engineering, Legal, Contingency (35%)				**$87,378**
	Total Estimated Project Cost				**$337,028**

Table 7. Grenada Dam - Option 3
Preliminary Cost Estimate - November 2001 (+50% / -30% accuracy)

Bid Item	Description	Quantity	Unit of Measure	Unit Costs	Total Amount Quantity x Unit Price
1	Mobilization and Demobilization	1	JOB	29,000	$29,000
2	Demolition of Existing Dam	1	JOB	7,000	$7,000
3	Structural Concrete	85	CY	850	$72,250
4	Excavation/Earthfill	1,200	CY	20.0	$24,000
5	Rock Riprap	200	CY	55.0	$11,000
6	Stream Water Control	1	JOB	30,000	$30,000
7	Sheet Piling	1,120	SF	20.0	$22,400
8	Metal and Fabrication	1	JOB	10,000	$10,000
9	Electrical Supply	1	LS	4,000	$4,000
10	Fish Screening	1	LS	15,000	$15,000
11	Pumping for Huesman Ditch	1	LS	7,000	$7,000
12	Mechanical	1	LS	4,000	$4,000
13	Modification to Pumping Intakes	1	JOB	30,000	$30,000
14	Site Work	1	LS	35,000	$35,000
	Total Construction Costs				**$300,650**
	Administration, Engineering, Legal, Contingency (35%)				**$105,228**
	Total Estimated Project Cost				**$405,878**

Table 8. Novy Dam Improvement Option Summary

Option	Description	Improves Passage	Improves Screening	Lowers Water Level	Estimated Capital Costs	Estimated Annual Operating Costs	Comments
Option 1	Do nothing, no modification or improvement	No	No	No	$0	$0	Leaves site open to future regulatory scrutiny and/or action.
Option 2	Replace existing dam with a pool-weir-chute check structure. Relocate screen structure to mouth of diversion channel. Provide pumping with screening at the mouth of the diversion channel. Provide power for screening and pumping.	Yes	Yes	Yes (approx 2 to 3 feet)	$224,000	$8,200	Pool-weir-chute will provide both upstream and downstream passage for all ages. Will eliminate long delivery channel and need for fish return passage. Fish screening will be pressure backwash.
Option 3	Replace existing dam with a pool-weir-chute check structure.	Yes	No	No	$152,000	$0	Leaves site open to future regulatory scrutiny and/or action with respect to fish screening. Pool-weir-chute will provide both upstream and downstream passage for all ages.
Option 4	Relocate screen structure to mouth of diversion channel. Provide pumping with screening at the mouth of the diversion channel. Provide power for screening and pumping.	No	Yes	Yes (approx 2 to 3 feet)	$178,200	$8,200	Leaves site open to future regulatory scrutiny and/or action with respect to fish passage. Fish screening will utilize pressure backwash for cleaning.

Table 9. Novy Dam - Option 2
Preliminary Cost Estimate - November 2001 (+50% / -30% accuracy)

Bid Item	Description	Quantity	Unit of Measure	Unit Costs	Total Amount Quantity x Unit Price
1	Mobilization and Demobilization	1	JOB	16,000	$16,000
2	Demolition of Existing Dam	1	JOB	4,000	$4,000
3	Structural Concrete	40	CY	850	$34,000
4	Excavation/Earthfill	800	CY	20.0	$16,000
5	Rock Riprap	50	CY	55.0	$2,750
6	Stream Water Control	1	JOB	20,000	$20,000
7	Sheet Piling	650	SF	20.0	$13,000
8	Metal and Fabrication	1	JOB	7,000	$7,000
9	Electrical Supply	1	LS	10,000	$10,000
10	Fish Screening	1	LS	25,000	$25,000
11	Pumping	1	LS	7,000	$7,000
12	Mechanical	1	LS	4,000	$4,000
13	Site Work	1	LS	7,000	$7,000
	Total Construction Costs				**$165,750**
	Administration, Engineering, Legal, Contingency (35%)				**$58,013**
	Total Estimated Project Cost				**$223,763**

Table 10. Novy Dam - Option 3
Preliminary Cost Estimate - November 2001 (+50% / -30% accuracy)

Bid Item	Description	Quantity	Unit of Measure	Unit Costs	Total Amount Quantity x Unit Price
1	Mobilization and Demobilization	1	JOB	11,000	$11,000
2	Demolition of Existing Dam	1	JOB	4,000	$4,000
3	Structural Concrete	40	CY	850	$34,000
4	Excavation/Earthfill	800	CY	20.0	$16,000
5	Rock Riprap	50	CY	55.0	$2,750
6	Stream Water Control	1	JOB	20,000	$20,000
7	Sheet Piling	650	SF	20.0	$13,000
8	Metal and Fabrication	1	JOB	7,000	$7,000
9	Site Work	1	LS	5,000	$5,000
	Total Construction Costs				**$112,750**
	Administration, Engineering, Legal, Contingency (35%)				**$39,463**
	Total Estimated Project Cost				**$152,213**

Table 11. Novy Dam - Option 4
Preliminary Cost Estimate - November 2001 (+50% / -30% accuracy)

Bid Item	Description	Quantity	Unit of Measure	Unit Costs	Total Amount Quantity x Unit Price
1	Mobilization and Demobilization	1	JOB	6,000	$6,000
2	Electrical Supply	1	LS	10,000	$10,000
3	Fish Screening	1	LS	25,000	$25,000
4	Pumping	1	LS	7,000	$7,000
5	Mechanical	1	LS	4,000	$4,000
6	Site Work	1	LS	7,000	$7,000
	Total Construction Costs				**$59,000**
	Administration, Engineering, Legal, Contingency (35%)				**$20,650**
	Total Estimated Project Cost				**$79,650**

Table 12. Shasta Dam Improvement Option Summary

Option	Description	Improves Passage	Improves Screening	Lowers Water Level	Estimated Capital Costs	Estimated Annual Operating Costs	Comments
Option 1	Do nothing, no modification or improvement	No	No	No	$0	$0	Leaves site open to future regulatory scrutiny and/or action. Will need to continue dredging activities.
Option 2	Replace existing dam with a water control check structure near the existing pump station. Maintain existing vertical fixed plate screen. Provide screening and piping to service the Kuck diversion. Improve fish return flow system and piping. Provide upstream channel modifications to eliminate dredging.	Yes	Yes	No	$336,000	$0	Removes a large portion of surface area behind the dam. Water control structure will provide both upstream and downstream passage for all ages. Will eliminate the need for dredging. Easier access for operation and maintenance.
Option 3	Replace existing dam with a water control check structure near the existing pump station. Install new fixed plate screening parallel to the stream channel within water control structure to allow lower water elevation. Provide pumping, screening and piping to service the Kuck diversion. Provide upstream channel modifications to eliminate dredging.	Yes	Yes	Yes (approx. 2 feet)	$406,000	SWA=$4,600 Kuck= $1,100	Removes a large portion of surface area behind the dam. Water control structure will provide both upstream and downstream passage for all ages. Will eliminate the need for dredging. Easier access for operation and maintenance. No need for fish return passage.

Table 13. Shasta Dam - Option 2
Preliminary Cost Estimate - November 2001 (+50% / -30% accuracy)

Bid Item	Description	Quantity	Unit of Measure	Unit Costs	Total Amount Quantity x Unit Price
1	Mobilization and Demobilization	1	JOB	24,000	$24,000
2	Demolition of Existing Dam	1	JOB	7,000	$7,000
3	Structural Concrete	50	CY	850	$42,500
4	Excavation/Earthfill	2,300	CY	20.0	$46,000
5	Rock Riprap	250	CY	55.0	$13,750
6	Stream Water Control	1	JOB	30,000	$30,000
7	Sheet Piling	960	SF	20.0	$19,200
8	Metal and Fabrication	1	JOB	7,000	$7,000
9	Piping for Kuck Diversion	1,000	LF	15	$15,000
10	Fish Return Flow Improvements	1	JOB	20,000	$20,000
11	Site Work	1	LS	25,000	$25,000
				Total Construction Costs	**$249,450**
				Administration, Engineering, Legal, Contingency (35%)	**$87,308**
				Total Estimated Project Cost	**$336,758**

Table 14. Shasta Dam - Option 3
Preliminary Cost Estimate - November 2001 (+50% / -30% accuracy)

Bid Item	Description	Quantity	Unit of Measure	Unit Costs	Total Amount Quantity x Unit Price
1	Mobilization and Demobilization	1	JOB	29,000	$29,000
2	Demolition of Existing Dam	1	JOB	7,000	$7,000
3	Structural Concrete	75	CY	850	$63,750
4	Excavation/Earthfill	2,300	CY	20.0	$46,000
5	Rock Riprap	250	CY	55.0	$13,750
6	Stream Water Control	1	JOB	30,000	$30,000
7	Sheet Piling	1,100	SF	20.0	$22,000
8	Metal and Fabrication	1	JOB	7,000	$7,000
9	Piping for Kuck Diversion	1,000	LF	15	$15,000
10	Pumping for Kuck Diversion	1	JOB	7,000	$7,000
11	Screening Relocation	1	JOB	35,000	$35,000
12	Site Work	1	LS	25,000	$25,000
	Total Construction Costs				**$300,500**
	Administration, Engineering, Legal, Contingency (35%)				**$105,175**
	Total Estimated Project Cost				**$405,675**

Table 15. Fiock Dam Improvement Option Summary

Option	Description	Improves Passage	Improves Screening	Lowers Water Level	Estimated Capital Costs	Estimated Annual Operating Costs	Comments
Option 1	Do nothing, no modification or improvement	No	No	No	$0	$0	Leaves site open to future regulatory scrutiny and/or action.
Option 2	Modify existing dam to include a pool-weir-chute passage/check structure. Relocate screening to the river channel. Provide power for screening operation.	Yes	Yes	No	$193,000	$0	Pool-weir-chute will provide both upstream and downstream passage for all ages. Fish screening will be vertical traveling or rotary drum.
Option 3	Replace existing dam with a pool-weir-chute passage/check structure. Relocate screening to the river channel and provide pumping. Provide grade control weirs to step down water elevation.	Yes	Yes	Yes (approx. 2 to 3 feet)	$289,000	$9,800	Pool-weir-chute will provide both upstream and downstream passage for all ages. Fish screening will be vertical traveling or rotary drum. Grade control weirs will be fish passable rock weirs.
Option 4	Remove existing dam. Relocate diversion points for ditches closer to the point of use. Provide grade control weirs, pumping, and screening at these new locations.	Yes	Yes	Yes (approx. 4 feet)	$178,200	Antonio=$6,500 Fiock=$6,500 Mariani=$1,600	Grade control weirs will be fish passable rock weirs or rock barbs.

Table 16. Fiock Dam - Option 2
Preliminary Cost Estimate - November 2001 (+50% / -30% accuracy)

Bid Item	Description	Quantity	Unit of Measure	Unit Costs	Total Amount Quantity x Unit Price
1	Mobilization and Demobilization	1	JOB	14,000	$14,000
2	Structural Concrete	30	CY	850	$25,500
3	Excavation/Earthfill	100	CY	20.0	$2,000
4	Rock Riprap	50	CY	55.0	$2,750
5	Stream Water Control	1	JOB	20,000	$20,000
6	Metal and Fabrication	1	JOB	4,000	$4,000
7	Screening Relocation	2	EA	25,000	$50,000
8	Electrical Supply	1	JOB	15,000	$15,000
9	Site Work	1	LS	10,000	$10,000
	Total Construction Costs				**$143,250**
	Administration, Engineering, Legal, Contingency (35%)				**$50,138**
	Total Estimated Project Cost				**$193,388**

Table 17. Fiock Dam - Option 3
Preliminary Cost Estimate - November 2001 (+50% / -30% accuracy)

Bid Item	Description	Quantity	Unit of Measure	Unit Costs	Total Amount Quantity x Unit Price
1	Mobilization and Demobilization	1	JOB	21,000	$21,000
2	Structural Concrete	30	CY	850	$25,500
3	Excavation/Earthfill	100	CY	20.0	$2,000
4	Rock Riprap	50	CY	55.0	$2,750
5	Stream Water Control	1	JOB	20,000	$20,000
6	Metal and Fabrication	1	JOB	4,000	$4,000
7	Screening Relocation	2	EA	25,000	$50,000
8	Electrical Supply	1	JOB	15,000	$15,000
9	Pumping for Diversions	2	EA	12,000	$24,000
10	Grade Control Rock Weirs	2	EA	20,000	$40,000
11	Site Work	1	LS	10,000	$10,000
	Total Construction Costs				**$214,250**
	Administration, Engineering, Legal, Contingency (35%)				**$74,988**
	Total Estimated Project Cost				**$289,238**

Table 18. Fiock Dam - Option 4
Preliminary Cost Estimate - November 2001 (+50% / -30% accuracy)

Bid Item	Description	Quantity	Unit of Measure	Unit Costs	Total Amount Quantity x Unit Price
1	Mobilization and Demobilization	1	JOB	13,000	$13,000
2	Removal Existing Dam	1	JOB	7,000	$7,000
4	Stream Bank Stabilization	1	JOB	4,000	$4,000
5	Stream Water Control	1	JOB	5,000	$5,000
9	Pumping for Diversions[1]	4	EA	12,000	$48,000
10	Grade Control Rock Weirs	4	EA	10,000	$40,000
11	Site Work	1	LS	15,000	$15,000
	Total Construction Costs				**$132,000**
	Administration, Engineering, Legal, Contingency (35%)				**$46,200**
	Total Estimated Project Cost				**$178,200**

Table 19. Hart and Blair Smith Diversions Invisible Weir Screen
Preliminary Cost Estimate - November 2001 (+50% / -30% accuracy)

Bid Item	Description	Quantity	Unit of Measure	Unit Costs	Total Amount Quantity x Unit Price
1	Mobilization and Demobilization	1	JOB	12,000	$12,000
2	Structural Concrete	25	CY	850	$21,250
3	Excavation/Earthfill	400	CY	20.0	$8,000
4	Rock Riprap	150	CY	55.0	$8,250
5	Stream Water Control	1	JOB	20,000	$20,000
6	Metal and Fabrication	1	JOB	8,000	$8,000
7	Screening	60	SF	125	$7,500
8	Air Burst System	1	JOB	15,000	$15,000
9	Grade Control Rock Weirs	1	EA	10,000	$10,000
10	Site Work	1	LS	15,000	$15,000
	Total Construction Costs				**$125,000**
	Administration, Engineering, Legal, Contingency (35%)				**$43,750**
	Total Estimated Project Cost				**$168,750**

FIGURES

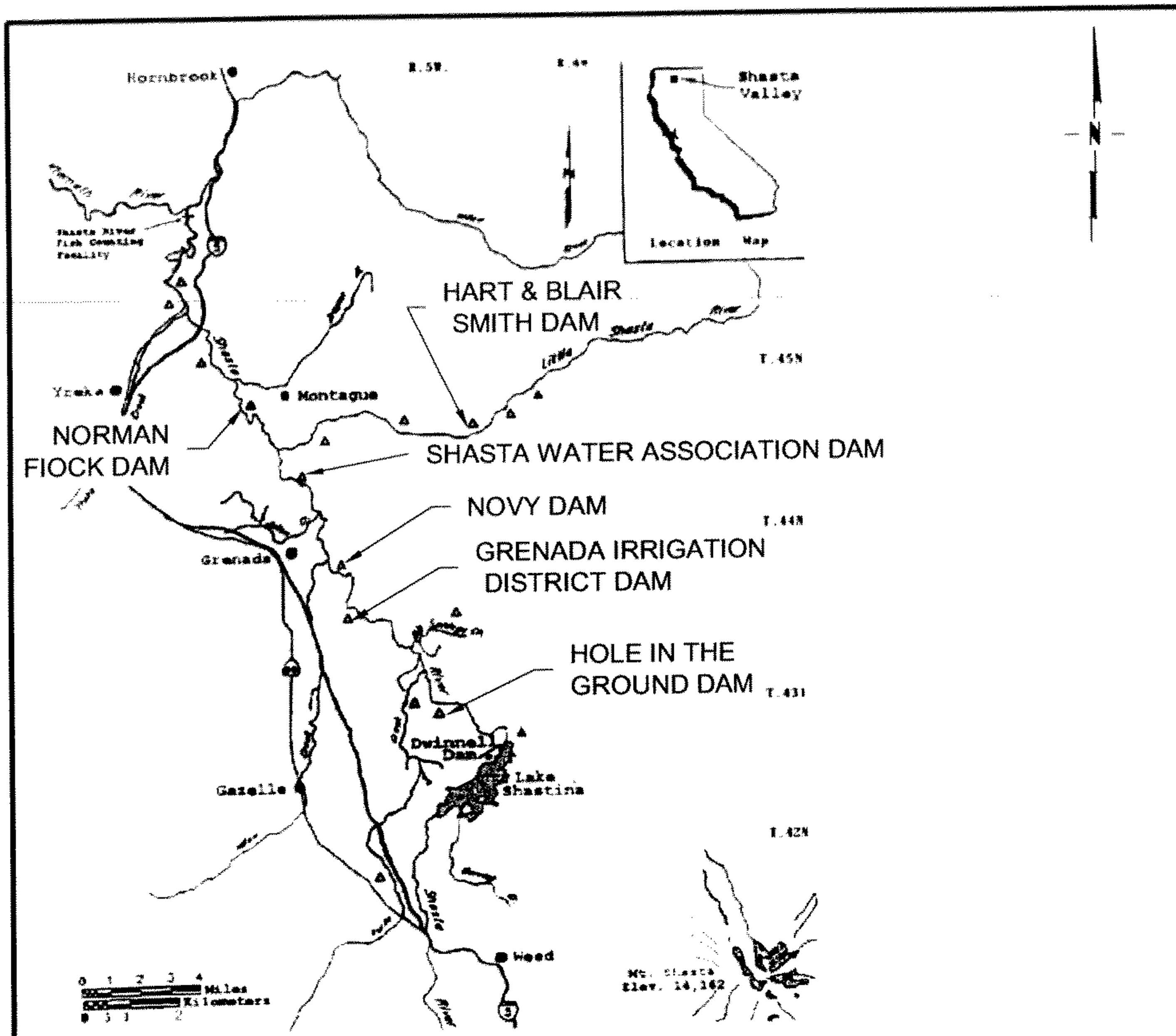
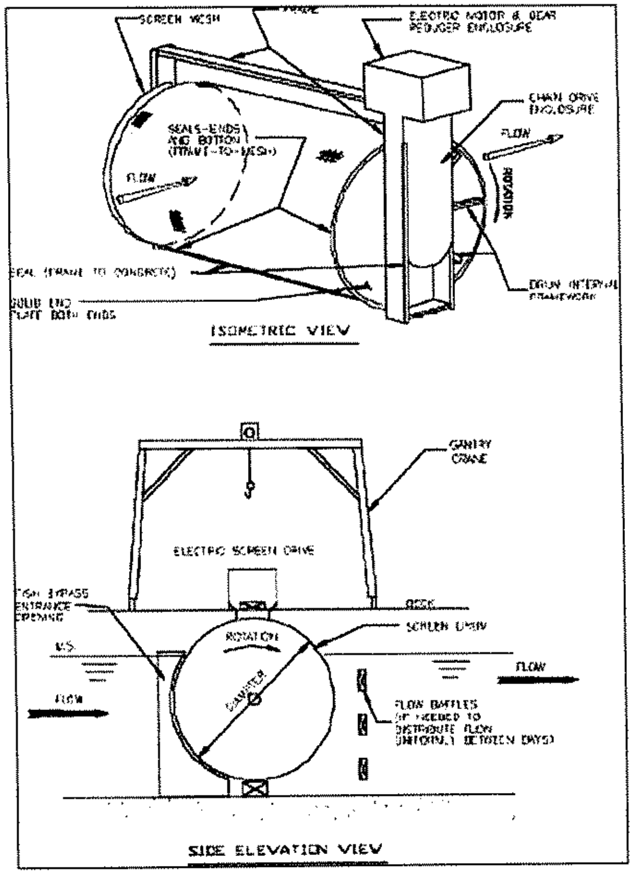


Figure 1. Site Location Map

(SOURCE: DWR 1990)

PROJECT NUMBER: 2140021	SHASTA RIVER PRELIMINARY ENGINEERING REPORT
DATE: 11/20/01	
DWG BY: JHW / DWG NO: 2140021F1	YREKA, CALIFORNIA
PROJECT MANAGER: GLA	
REVISED:	CES CASCADE EARTH SCIENCES A Valmont Industries Company



(SOURCE: Nordlund 1996)

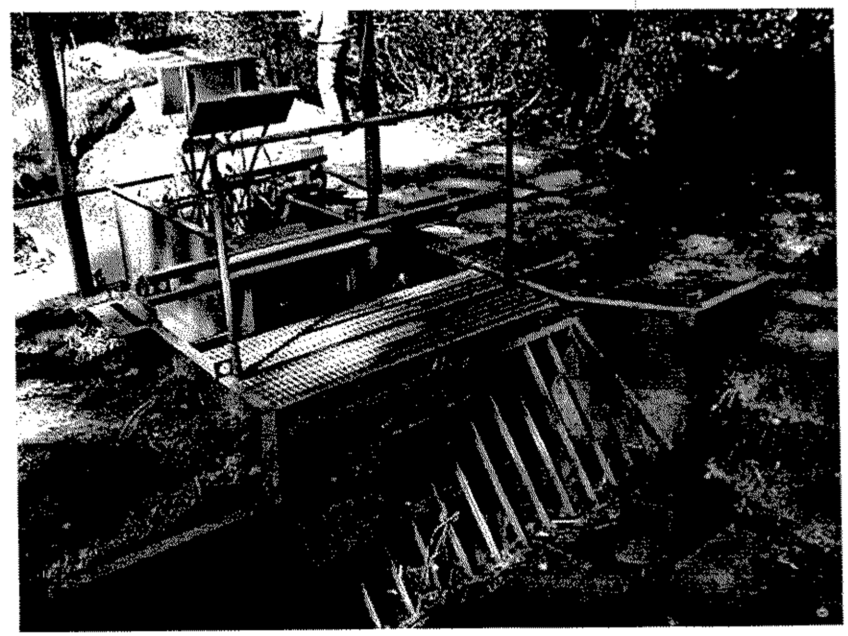


Figure 2. Typical Rotary Drum Site Installation

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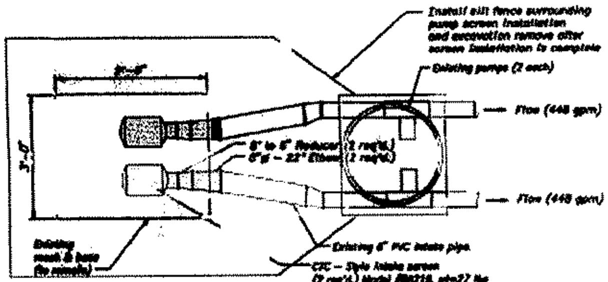
DATE: 4/10/02 2:16 PM	
DWG. LT / DWG NO: 2140021F2.dwg	Yreka, California
PROJECT MANAGER: GA	
REVISED:	CES CASCADE EARTH SCIENCES A Valmont Industries Company



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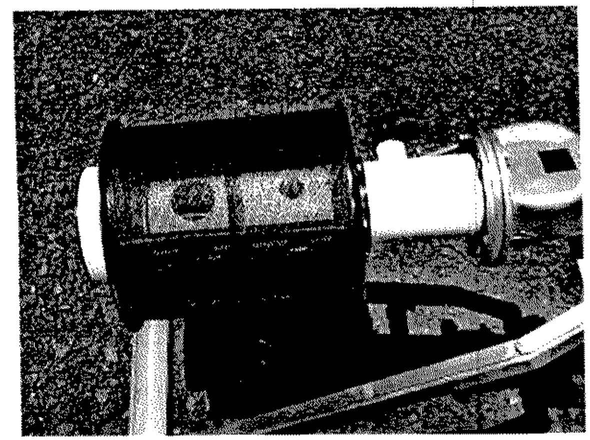

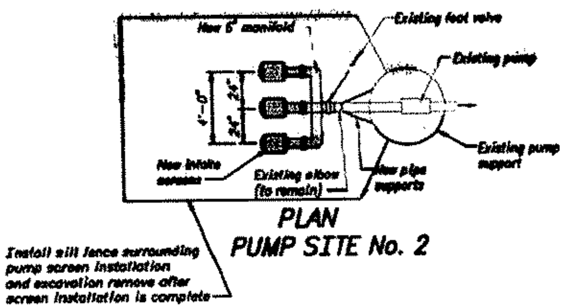

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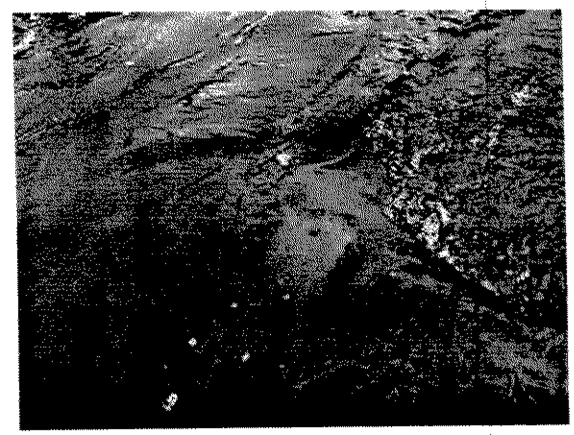

Figure 3. Typical Pressure Backwash Installation

(SOURCE: BOR 2001)

PROJECT NUMBER: 2140021	Shasta River Preliminary Engineering Report
DATE: 11/01	
DWG. LT / DWG NO: 2140021f3	Yreka, California
PROJECT MANAGER: GA	
REVISED:	CES CASCADE EARTH SCIENCES A Valmont Industries Company

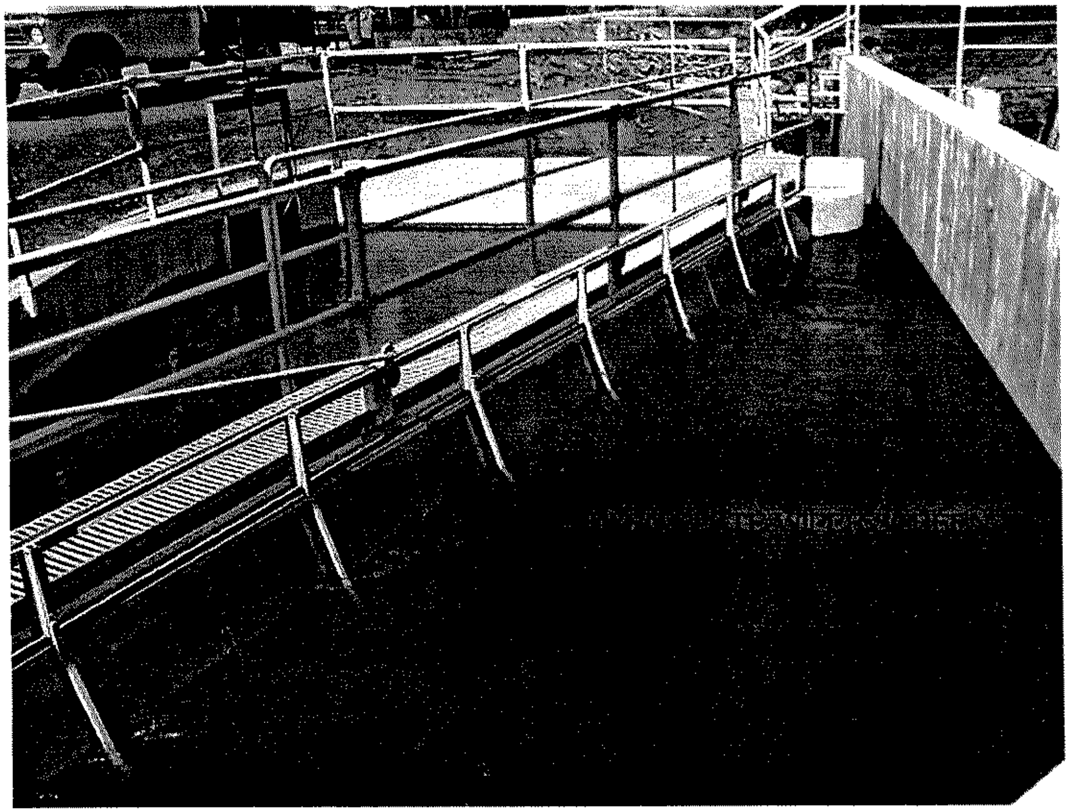

Figure 4. Water Control Structure with Vertical Fixed Plate

PROJECT NUMBER: 2140021	Shasta River Preliminary Engineering Report
DATE: 11/21/01 12:27 PM	
DWG. LT / DWG NO: 2140021F4.dwg	Yreka, California
PROJECT MANAGER: GA	
REVISED:	CES CASCADE EARTH SCIENCES A Valmont Industries Company

(SOURCE: CES)